European Bank
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International conference "Technologies in horticulture: trends and opportunities for Georgia"

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Food and Agriculture Organization of the United Nations

Progressive approaches to precision horticulture in the face of global climate change - main directions and challenges in Georgia

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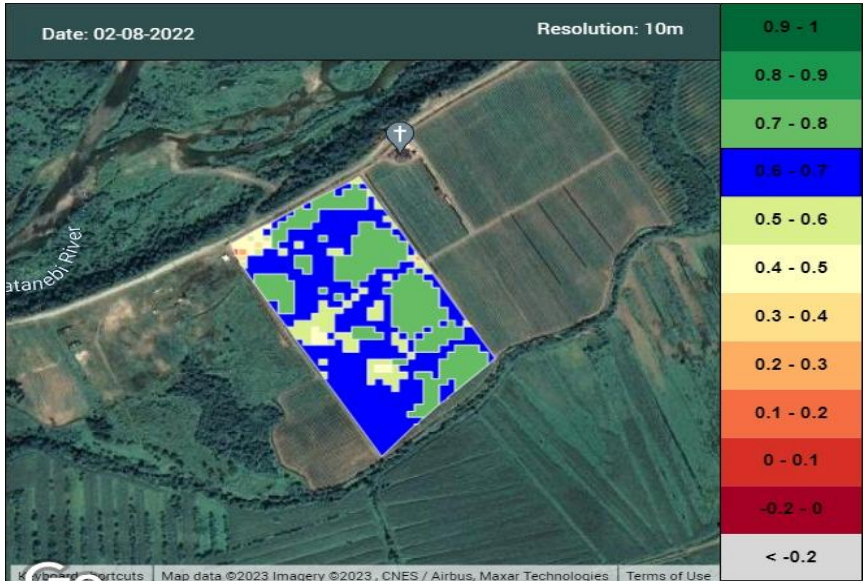
სოფლის მეურნეობის
სამეცნიერო-კვლევითი ცენტრი



Global climate changes and expected challenges

- It is proved fact that in the world global climatic changes in progress
- Georgian Fruit growers-farmers often has   following questions
- How Climate change is real in Georgia
- What negative climate Effect A expected specifically in Georgia ?
- What risks will be wait in orchards ?
- What can do in short term and long term in this case
- How can precise technologies help us in this directions?

Climate indicators by region - temperature - (1986-2015) VS (1956-1985)

კახეთსა და იმერეთში ჰაერის საშუალო ტემპერატურა 1986–2015 წლებში (Tmean) და ცვლილება 1956–1985 წლების მიმართ (ΔTmean)

თვეები	1	2	3	4	5	6	7	8	9	10	11	12	გაზ.	ზაფ.	შემ.	ზამ.	წლ
კახეთი																	
Tmean, ^0C	1.6	2.5	6.6	11.9	16.4	21.1	23.9	23.7	19.2	13.5	7.3	3.0	11.7	22.9	13.3	2.3	12.6
ΔTmean, ^0C	0.47	0.54	1.03	0.16	-0.25	0.95	0.68	1.20	0.87	1.06	-0.15	-0.08	0.31	0.94	0.60	0.30	0.54
იმერეთი																	
Tmean, ^0C	4.2	4.9	8.2	13.3	17.6	21.1	23.8	24.3	20.6	15.7	9.9	6.0	13.1	23.1	15.4	5.1	14.2
ΔTmean, ^0C	0.14	0.16	0.29	0.14	0.03	0.44	1.14	1.56	1.10	1.10	-0.19	-0.06	0.16	1.05	0.67	0.07	0.49

Source : National Environment Agency/ Source The National Environment Agency , 2020

Some current climate indicators by region - Precipitation (1986-2015) VS (1956-1985)

Kakheti	Telavi	Precipitation in 1986-2015; mm	27	35	50	88	123	99	62	69	66	67	47	31	261	230	180	93	765
		ΔPr (1986-2015;1956-1985), mm	1	0	0	9	12	-24	-16	-4	-2	14	7	2	21	-44	19	3	-1
		ΔPr (1986-2015;1956-1985), %	4	0	0	11	11	-20	-21	-5	-3	26	18	7	9	-16	12	3	-0.1
	Lagodekhi	Precipitation in 1986-2015; mm	47	59	85	115	135	125	105	113	110	113	80	47	334	343	303	154	1134
		ΔPr (1986-2015;1956-1985), mm	9	11	7	14	8	2	8	26	4	19	17	9	29	36	40	29	134
		ΔPr (1986-2015;1956-1985), %	24	23	9	14	6	2	8	30	4	20	27	24	10	12	15	23	13
	Sagarejo	Precipitation in 1986-2015; mm	27	38	57	95	104	87	56	52	60	82	49	32	256	196	191	97	741
		ΔPr (1986-2015;1956-1985), mm	-5	-3	-6	5	-6	-21	-25	-16	-10	20	6	4	-7	-62	16	-4	-57
		ΔPr (1986-2015;1956-1985), %	-16	-7	-10	6	-5	-19	-31	-24	-14	32	14	14	-3	-24	9	-4	-7
	Dedoplistskaro	Precipitation in 1986-2015; mm	29	31	46	66	95	75	50	39	55	57	40	21	208	163	153	81	604
		ΔPr (1986-2015;1956-1985), mm	6	2	1	3	9	-30	-4	-6	9	7	10	-2	13	-40	26	6	5
		ΔPr (1986-2015;1956-1985), %	26	7	2	5	10	-29	-7	-13	20	14	33	-9	7	-20	20	8	1
Mtskheta-Mtianeti	Pasanauri	Precipitation in 1986-2015; mm	50	51	69	102	139	128	95	99	68	85	64	57	310	322	216	158	1005
		ΔPr (1986-2015;1956-1985), mm	4	-3	-2	-5	6	5	-14	20	-16	26	11	9	-1	11	21	10	41
		ΔPr (1986-2015;1956-1985), %	9	-6	-3	-5	5	4	-13	25	-19	44	21	19	-0.3	4	11	7	4
	Tianeti	Precipitation in 1986-2015; mm	30	37	43	78	93	94	58	66	51	63	45	34	215	218	159	101	694
		ΔPr (1986-2015;1956-1985), mm	0	-4	-12	-12	-41	-25	-28	-17	-23	9	1	3	-65	-70	-13	-1	-149
		ΔPr (1986-2015;1956-1985), %	0	-10	-22	-13	-31	-21	-33	-20	-31	17	2	10	-23	-24	-8	-1	-18
		Precipitation in 1986-2015; mm	18	22	30	63	82	80	39	40	32	48	35	21	175	159	115	61	510

Source : National Environment Agency/ Source The National Environment Agency , 2020

trends of climatic changes (1986-2015) VS (1956-1985)

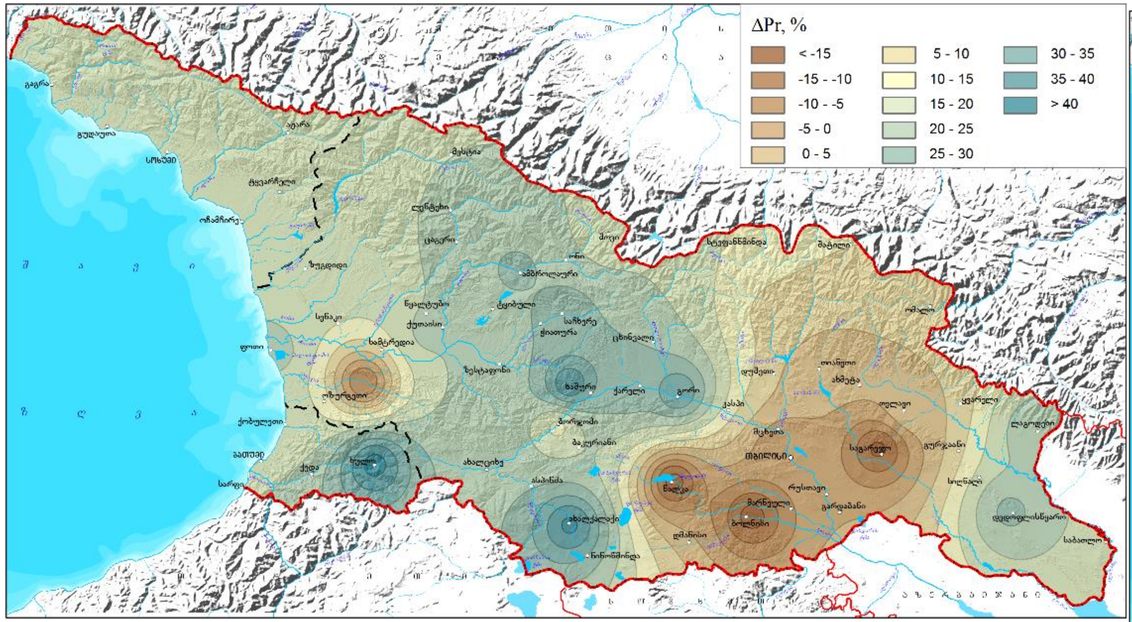
- **Current climate change** The average annual temperature increased by 0.54 ^{0}C in Kakheti, and by 0.49 ^{0}C in Imereti.
- **average air temperatures** mainly occurs in **the June-October** period
- in November-December there is a slight decrease in the average temperature.
- August **temperature is increased by** 1.18-1.56 ^{0}C
- The temperature of the summer months is increased by 0.89 - 1.56 C
- In the summer period, **precipitation decreases by 20-25 mm**
- **The annual amount of precipitation** is mainly decreasing
- **Peak extremes of precipitation and temperature** have increased
- The duration of drought periods has increased

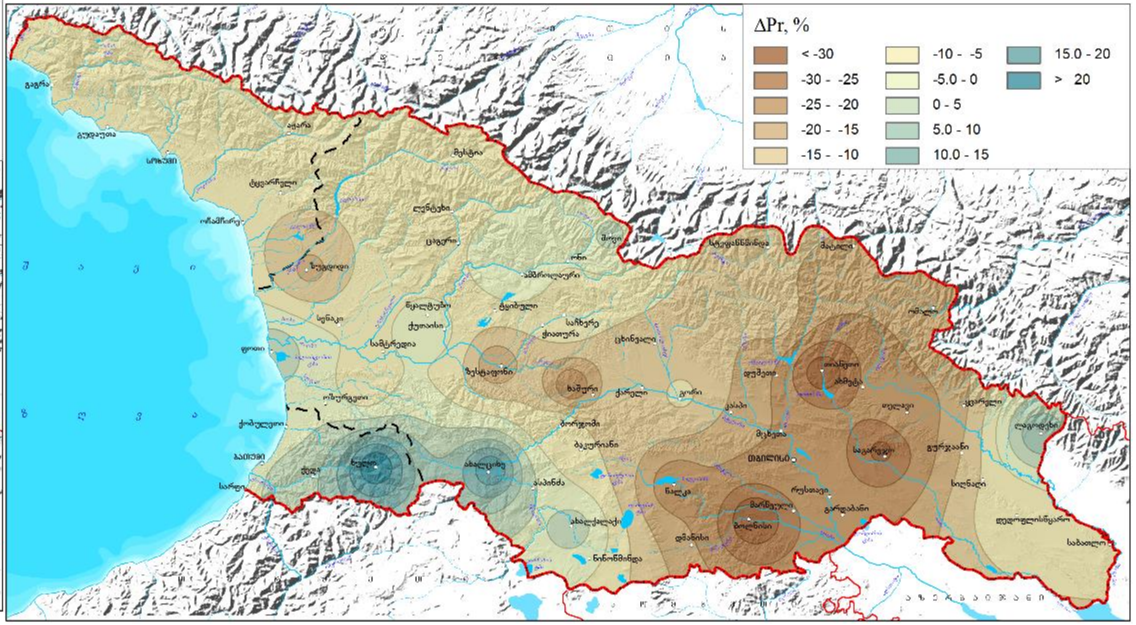
Forecasting models of climatic changes (2041 - 2070) VS (2071 - 2100) - Methodology

The following climate indices are used to characterize climate change :

- **Average air temperature** in the years 1986–2015 (Tmean) and the change compared to the years 1956–1985 (DTmean)
- **precipitation quantity** 1986-2015 (Pr) and _ change in percentages of 1956-1985 to (DPr , %)
- **Future climate change** is projected/estimated for 2041–2070 (first projection period) and 2071–2100 (second projection period) by comparing mean values of meteorological parameters with corresponding values for 1971–2000. The mentioned data **are taken based on the simulation of the relevant climate change scenario.**
- **Growing Season Length (GSL)**
- **Number of days when average temperature TM ≤ 10 ^{0} C (TMlt10)**
- **Heat Wave Number (HWN)**
- **GDDgrown -** sum of active temperatures. The annual sum of the positive values of the daily (TM - n) difference (TM > n), where TM is the average daily temperature and n is the user-specified base temperature for the location.
- **WSDI -** Warm period duration, the number of days per year with at least 6 consecutive days of maximum daytime temperature, TX > 90th percentile. **TX90p** – Hot Days. Percentage of days when TX > 90th percentile.
- **Rx1day –** 1-day maximum of precipitation. The maximum amount of precipitation in one day during the month or year.

Forecast models of climate change (2041-2070) and (2071-2100)





Source : National Environment Agency/ Source The National Environment Agency , 2020

Predicted changes in precipitation according to the proposed models

- **Precipitation in Georgia (Kakheti).** first predictive in the period (**2041-2070)** of precipitation annual quantity will be reduced additionally by 8% . Important in winter An increase is expected (by 15%) , remaining three in the season It is decreasing , maximum decline will observed Spring and summer (by 21%).
- **Second predictive in the period (2071-2100 years) in Kakheti** annual Precipitation It is reduced by 19% . reduction especially it's important in spring (by 28%) and in autumn (by 16%). only It's summer increase (by 6%).
- **Western Georgia** all in the season is noted precipitation decrease (8-1 3 %). within) Imereti Precipitation is reduced all in the season the most It is noticeable reduction in summer and In the fall (both by 14% in the season).

Climate changes influence on productivity of orchards

Heat stress will result The reduction of the surface area of the leaf of fruit trees and, accordingly, the reduction of the yield .

- **Solar radiation will increase fruit sunburns**
- **The duration of drought periods prolonged**
- **Due to the change in the temperature regime,** the load of harmful pathogens will increase and, accordingly, the need to use more integrated plant protection measures.
- **Unfavorable meteorological cases** (spring late and autumn early Frosts , hail and other) will growth ,
- High of temperatures (+32-35 ^{0}C and more) **days cycles will increase**
- **will decrease** of snow cover period
- **The amount of anomalous precipitation will increase ,** which will lead to excess water and temporary flooding in the plains of west Georgia
- **will intensify hot (Fionic) Winds** that will increase fruit drop and reduce yields

Application of progressive elements of precision horticulture - to adapt to climate change -1

- Real and virtual Agrometeo stations setup in orchards Hydrothermal analisis for the real reflection of the regime . Based irrigation schemes appropriate adjusment
- Use of Forecasting meteorological station models - pesticides and the number of agrochemicals and of use period appropriate correction - spraying in the evening and in the morning in hours
- Intensive use of methods based on forecasting the spread of harmful pathogens (pheromone monitoring and phenological models) for optimal prevention of their spread

Use of progressive elements of precision horticulture - to adapt to climate change - 2

- Smart drip irrigation Arrangement of systems
- Precision irrigation based on soil , air and fruits monitoring appropriate Modern sensors and Dendrometers
- Smart sensors use soil optimal humidity to maintain and   of water to save .
- Regulated deficit irrigation (RDI) approaches use

Use of progressive elements of precision horticulture - to adapt to climate change -3

- Optimization of irrigation and drainage systems using multispectral analisis
- Use of unmanned aerial vehicles for spraying and scanning the surface of the soil
- In intensive fruit orchadss use Dynamic (moving) agrosolar systems (photovoltage) Arrangement - which is intended for plants from the sun to protect and In itself " green " electricity to get that intended will be village in farming to use .
- Building Digital Ecosystems for Orchard Management - Digital Agriculture Approaches - Applications
- Unmanned electric tractors and the use of cobots

Scientific-research center of agriculture

satellite and drone spectrum images Use for optimization of agrotechnical measures in orchards and vineyards

Concept: Received by satellite and drones image Use remote Sensing approaches Use (NDMI, NDVI and others) irrigation water optimization , plant growth, soil Fertility assessment and to monitor pathogens

project Description

- Satellite imagery special providers (Landsat, Planet, Skywatch and etc.) and Taken by local drone (Ebee Ag). Use of materials 1.0 ha , 10 ha and 100 ha on plots test plots to check and for monitoring .
- real in time conducted of research and satellite /drones pictures comparison . Correlation specification.
- research Based on the climate for Georgia of change for softening satellite image Adequate use approaches development
- **expected Results :**
- project farmers will help satellite image proper in use productivity to increase purpose

Types of spectral analysis

- NDVI (Normalized Difference Vegetation Index),
- NDMI (Normalized Difference Moisture Index) ,
- MNDWI (Modified Normalized Difference Water Index)
- GNDVI (Green Normalized Difference Vegetation Index),
- REP (Red Edge Position),
- WI (Water Index),
- TCARI (Transform chlorophyll absorption in reflectance index)
- ARI (Anthocyanin Reflectance Index) and others

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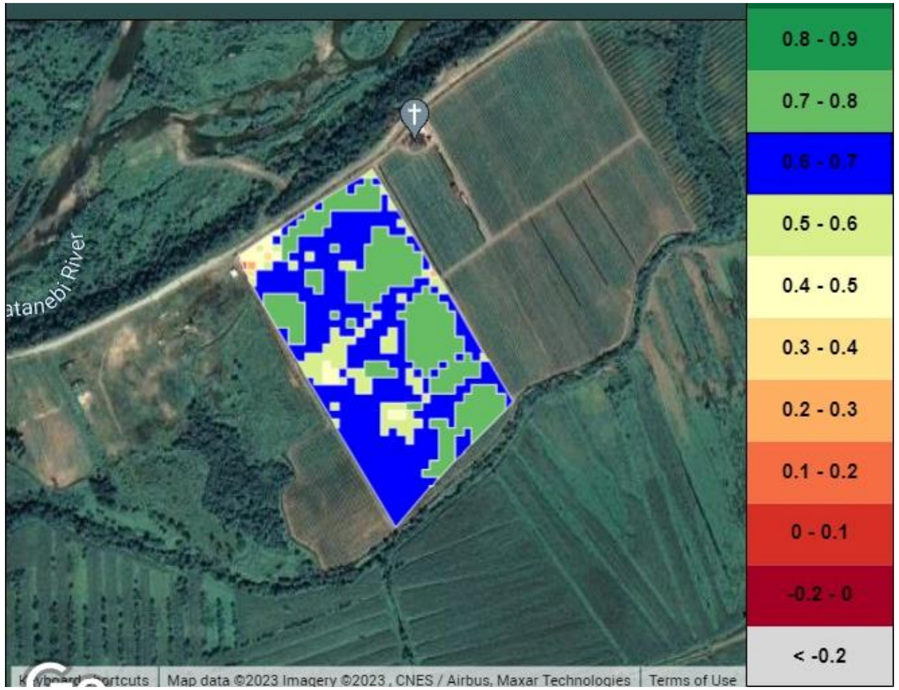
Pilot Multispectral Analysis Studies NDMI Satellite Images - SRCA

(ND M I): - moisture index - humidity Normalized difference index
ND M I - -1.0 - 1.0
0. 2 -0. 5 Requires watering
0.5 – 0.7 does not need watering
0.8 – 1.0 excess water
1 0 * 10 meter pixels , % area distribution

Pilot multispectral analysis studies - NDVI and LAI SRCA



(NDVI): - vegetation index - vegetation Normalized difference index
NDVI range - -1.0 - 1.0
0 - land without vegetation
0.1 -0.5 Weak development
0.6 and above - strong development

(LAI) Leaf Area Index The ratio of leaf area with land area
0 -2 is low,
3-4 is high
1 0 * 10 meter pixel ,
% distribution of areas

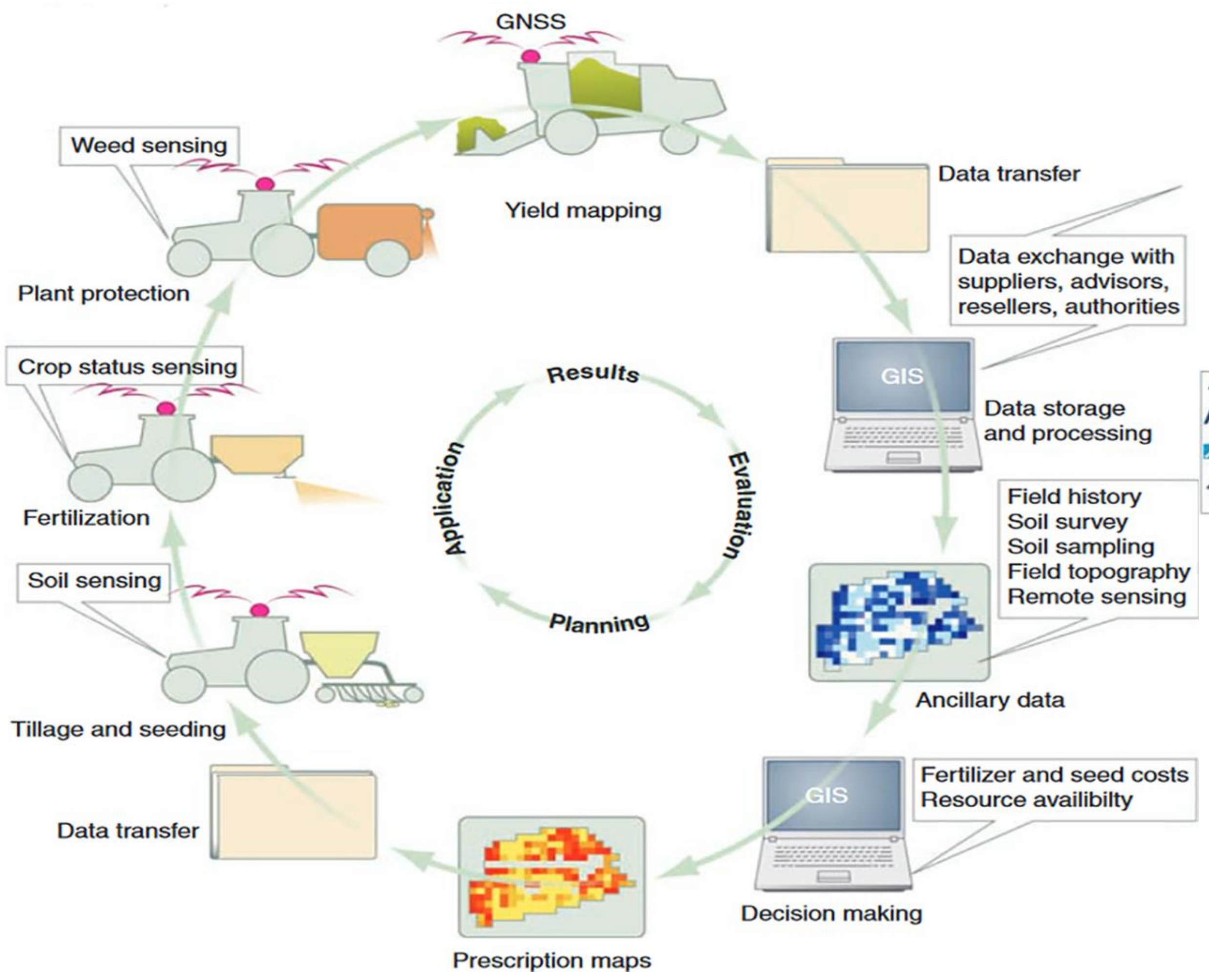
Challenges - Georgian Fruit Farmers' Opinions Regarding Precious Technologies

- **Pragmatic approach** - everyone reads price or availability first and then asks what it will help with
- **Weather stations**

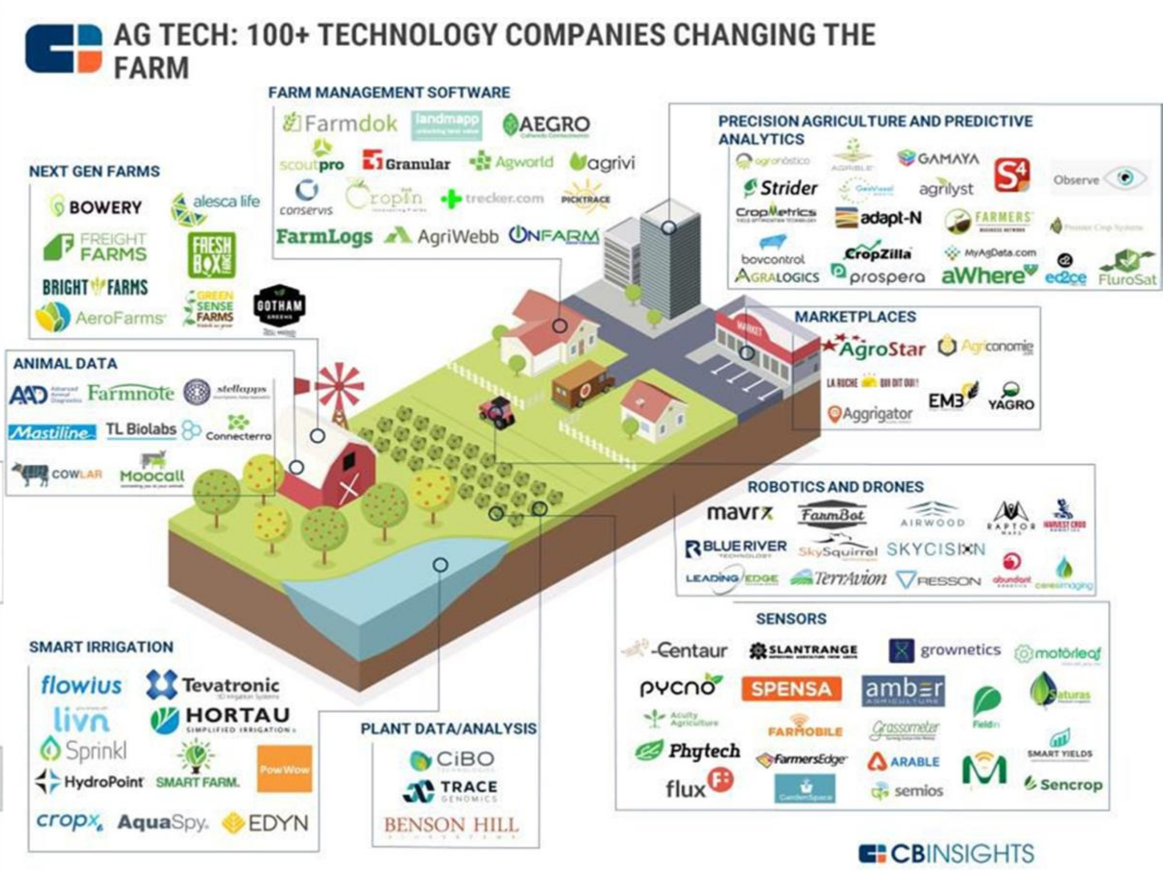
- ❑ **Standard question 1.** We heard that during the spread of diseases, medication should be administered, but it's raining and we can't do it. What is the benefit of this system?
- ❑ **Standard question 2 - the weather station** recommends me more medicine than I do, that is, should I use more intensive medicine? Then I will be more at a loss
- ❑ **Spectral analysis** - it advises me to apply more fertilizer to a specific area, so I should be spend more ?

- **NDVI shows** that a particular area is not irrigated well. But my system does not work separately in this specific area, what should I do to make a new system? If I turn it on additionally, I will lose too much water.
- **Drone** - spraying with a drone in the orchard - it is probably good for 1 ha, but how long will it take me to do it for 20 ha?
- **Drone** – might crash down?
- **Soil moisture sensors -** as many as I installed, they all show different datas
- **Precision fruit growing?** - It is not available for small farmers and it is very expensive
- **Precious fruiting only helps me to make a decision?** The real problem lies in the execution stage, not the decision.

Basic components of precision horticulture



Key driving sectors of precision horticulture



Source: Who drives the digital revolution in agriculture? A review of supply-side trends, players and challenges R. _ Birner , T. _ Daum , C. _ Pray **Applied Eco Perspectives Pol, Volume: 43, Issue: 4, Pages: 1260-1285, 2021**

Guidelines for solving the given questions

- Bringing precise approaches to practical use - confirmation - validation – deliver to the farmer **through practical demonstration**
- **The precise components** require additional adaptive studies in terms of crop and varieties
- Avoiding **raw technologies for bad results**
- **Decision –** implementation chain proper accomplishment
- It is necessary to create supply chain of precision **horticulture -** - products, service, spectrum, training

Opinions - some directions for the development of precise (precise) fruit growing

1 stage, short term

- **agrometeorological stations,**
- Hazard (frost, drought, etc.) notification systems, satellite and drone **spraying and spectral analysis,**
- Irrigation-fertigation **automation-with applications on smartphones**
- **A/Soil humidity measuring sensors** - their installation, training, use, interpretation, data verification with the real situation
- Stage 2 **- long-term - pathogen monitoring, Self moved drones and GPS guided or self-propelled (electric) tractors, agrovoltage, intelligent Smart valves , segmentation of irrigation blocks, robots- co -bots and others.**

Some useful precision agriculture resources - available - free

- **Satellite Imagery and Spectral Analysis Platform** https://eos.com/find-satellite/sentinel-2
- **Online resource for designing a precise nutrition** system https://i-plantnutrition.com/
- **Drone Control Virtual Instructor App -** https://www.dji.com/downloads/djiapp/dji-virtual-flight
- **Weed and pest identification** https://www.xarvio.com/us/en/products/scouting.html
- **Weather forecast resource** - MeteoBlue

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Questions???

Thanks for your attention!!!

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